suggested

CO-OP ELECTRIFICATION ADVISER TRAINING OUTLINE

3

WATER SYSTEMS AND PLUMBING

REA

RURAL ELECTRIFICATION ADMINISTRATION U.S. DEPT. OF AGRICULTURE

1/50

PURPOSES OF THIS OUTLINE

This is one of a series of outlines prepared by REA as an aid in planning and arranging training schools for co-op electrification advisers. Each outline deals with a power use subject or with some aspect of cooperative principles and practice or with a particular method or technique of getting information to people. These are the three principal fields in which electrification advisers need to be skilled. Each booklet contains both suggested subject matter and suggestions as to how the material might be presented, with an indicatior of a suitable time schedule. The booklet is thus useful as a guide to committees in charge of training schools, as an aid to the instructors, and as a subject matter manual that may be distributed to participants at the close of a training session for study and future reference. Subjects available or in preparation are listed below by title and number. *It is suggested that committees planning such training schools keep in mind the need of training in all three types of subject matter and, insofar as practicable, make use of the outlines in a balanced combination.*

LIST OF SUBJECTS

An ORIENTATION OUTLINE (unnumbered) covers all three fields of information. It is to provide the subject matter for an initial school that will give co-op officials basic background information and an understanding of the nature and scope of the educational job to be done.

NO.	POWER USE SUBJECT	NO.	CO-OP SUBJECT	NO.	METHOD OR TECHNIQUE
1	Farm and home Wiring	100	Value of Co-op Membership	200	Getting News to Members (Newsletters and State Paper Columns)
2	Farm Motors	101	Integrating Power Use and Co-op Education	201	Using the Radio
3	Water Systems and Plumbing	102	The REA Program and Co-ops	202	Co-op Reports and Non-periodical Publications
4	Electric Ranges	103	The Electric Co-op — What It Is	203	Making Effective Talks
5	Laundry Equipment	104	The Co-op Movement — Here and Abroad	204	Demonstration Techniques
6	Poultry Production	105	Co-op Bylaws	205	Methods and Results of Adult Education
7	Refrigerators, Home Freezers, Walk-Ins	106	Establishing Member Ownership	206	Effective Meetings
8	Small Appliances	107	Assuring Member Participation	207	Photography and Motion Pictures
9	Dairying	108	Co-op Tax Status	208	Working with Newspapers
10	Pig Brooding	109	Annual Meetings	209	Exhibits and displays
11	Farm, Home and School Lighting	110	Co-op's Place in the Community	210	Working with Rural Youth
12	Farm Shop	111	Cooperation Between Co-ops	211	Working with Community Organizations
13	Pump Irrigation				
14	Garden Watering				
15	Electric Hotbeds				
16	Elevating, cleaning and grading farm crops				
17	Drying grain, hay, peanuts, etc				
18	Heating, cooling, ventilating				
19	Cleaners, dish washers				
20	Kitchen planning				

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PROPOSED PROGRAM

The amount of subject matter that an electrification adviser should know in the fields of water systems and plumbing is so great that it is doubtful that it can be taught effectively in less than four days' time. If less than this amount of time is available in a school, certain subjects should be omitted completely and another school held at which they are covered. Even in four days' time, certain subjects can be little more than "touched on" if the instruction is complete on the remaining subjects.

The instruction proposed here makes no attempt to teach electrification advisers how to install water systems or plumbing. Instead, it aims at teaching what needs to be known if farmers are to be advised soundly on what they need to know about these subjects.

The "Suggested Instructors" indicated below are the types of persons who may be expected to give good instruction. Other persons with comparable background and experience may be equally well suited.

FIRST DAY

Subject	Suggested Instructors
1. Limitations on Water Supply (quantity and quality) - 1 hour a. Capacity of source b. Depth of well c. Type of well d. Pump capacity e. Water contamination f. Minerals	Specialist from State Health Department, State or College Geologist
2. What Makes a Pump Pump - 1 hour a. Atmospheric pressure (suction side) b. Power, design, strength of parts (pressure side)	College or Extension Specialist, Manufacturer's Engineer
3. Water Systems - 4 hours a. Gravity, hydropneumatic, pneumatic b. Pumps - Shallow well and deep well (1) Reciprocating (2) Turbine (3) Centrifugal (4) Rotary (5) Jet c. Motors - Split phase, capacitor, repulsion-induction d. Pressure tanks - Sizes e. Pressure switches - Range adjustment, differential adjustment f. Air volume controls - Three types g. Pressure safety releases	REA Specialist, College or Extension Specialist

SECOND DAY

Subject	Suggested Instructor
4. Water Pipes - 1 hour a. Kinds c. Layout b. Size determination	REA Specialist, College or Extension Specialist
5. Soil, Waste, and Vent Pipes - 30 minutes a. Kinds c. Layout b. Sizes d. Yard sewer	Health Department Specialist, College or Extension Specialist, Qualified Plumber
6. Septic Tanks and Disposal Fields - 2½ hours a. Tank size, type, dimensions, location b. Field arrangement, depth, size	Health Department Specialist, College or Extension Specialist, Portland Cement Association Specialist
7. Water Heaters - 1 hour a. Range boilers b. Side-arm c. Storage (1) Single element (2) Twin element (3) Independent and inter-connected thermostats (4) Sizes d. Safety releases - Temperature and temperature-pressure	Manufacturer's Specialist, REA Specialist
8. Water Conditioners - 1 hour a. Softeners (1) Principles and operation (2) Determining size (3) Types (4) Measuring water hardness b. Mineral removal (iron, etc.) c. Taste and odor removal d. Acidity and alkalinity control	Manufacturer's Specialist, Health Department Specialist, REA Specialist

THIRD DAY

Subject	Suggested Instructor
9. Farm Water Uses - 30 minutes a. Stock tanks e. Service b. Individual cups f. Freezing problems c. Poultry d. Milk house	Pump Manufacturer's Representative, College or Extension Specialist
10. Miscellaneous Water Uses - 30 minutes a. Lawn sprinkling b. Machinery washing and servicing c. Pump problems connected with continuous use over a considerable time	Manufacturer's Representative

THIRD DAY - continued

Subject	Suggested Instructor
11. Plumbing Fixtures - 1 hour a. Sinks - Styles, materials, sizes b. Lavatories - Styles, materials, sizes c. Water closets - Types, characteristics d. Bathtubs - Types, sizes e. Showers - Stalls, heads, controls f. Laundry tubs - Materials, types	Manufacturer's or Distributor's Representative, Extension Home Equipment Specialist
12. Planning the Bathroom - 1½ hours a. Fitting to space b. Relation to other rooms c. Relation to outside entrances d. Ventilation e. Relation to sewage system f. Size g. Arrangement of fixtures h. Facilities for farm workers	Home Equipment Specialist, Home Management Specialist
13. Planning the Kitchen for Water Use - 1 hour a. Sink permanently located b. Kitchen types c. Work centers d. Amount and arrangement of space e. Location in house	Home Management Specialist
14. Planning the Laundry Room and Farm Workers' Wash Room - 1½ hours a. Location b. Work centers c. Arrangement	Home Management Specialist

FOURTH DAY

Subject	Suggested Instructor
15. Planning the Water System - 1 hour a. Determining water uses b. Locating places of water use c. Determining needed well improvement d. Selecting the right "water system" (1) Pump capacity to meet needs (2) Suction and pressure conditions (3) Tank size (4) Motor size for pressure and running conditions e. Service pipe arrangement and sizes (1) For present needs (2) For future needs f. Distribution pipe arrangements and sizes (1) For present needs (2) For future needs	Extension Specialist, Manufacturer's Specialist

FOURTH DAY - continued

Subject	Suggested Instructor
16. Planning the Sewage Disposal System-1 hour a. Soil stack b. Waste stack c. Venting d. Fixture drains e. House drain f. House sewer g. Septic tank disposal field (1) Relation to sources of sewage (2) Relation to ground slope (3) Relation to well (4) Size, design, arrangement	Extension Specialist, Health Department Specialist
17. Wiring for Pumps and Water Heaters - 30 minutes	REA Engineer, Wiring Inspector
18. Review, Questions, and Special Problems - 30 minutes	Meeting Chairman, assisted by various instructors
19. Practice Planning - 3 hours Visit a farm, collect pertinent data, and then in a group discussion, plan the system for the farm	Led by a manager, an electrification adviser, or Extension Specialist, assisted by the various instructors

APPROPRIATE DEMONSTRATION AND PRACTICE EQUIPMENT

Equipment Which Should Be Present

1. One operating dealer's demonstration water system
2. One shallow well reciprocating pump
3. One deep well reciprocating pumping head
4. One deep well pump cylinder
5. One deep well jet pumping head
6. One deep well jet assembly
7. One automatic pressure switch
8. One air volume control valve
9. One pressure release valve
10. One section of cast iron soil pipe
11. One section of vitrified clay or concrete sewer pipe

Other Helpful Equipment

12. Four operating dealer's demonstration water systems - shallow well reciprocating, deep well reciprocating, jet, and shallow well turbine
13. One shallow well turbine pump
14. One shallow well rotary pump
15. Three air volume controls - for shallow well reciprocating pump, for deep well reciprocating pump, and aspirator type
16. Both steel pipe and copper tubing with appropriate fittings
17. Assortment of fittings for cast iron soil pipe
18. Temperature - pressure release valve
19. Frost-proof hydrant
20. Two-element storage water heater with inter-connected thermostats
21. Water softener
22. Livestock drinking cup
23. Automatic poultry waterer
24. Stock tank heater
25. Assortment of kitchen sinks
26. Lavatory
27. Wash-down water closet, reverse trap water closet, and siphon-jet water closet
28. Leg-type bathtub, apron-type bathtub, and universal-type bathtub.
29. Assortment of shower heads
30. Scale model of concrete septic tank

ADDITIONAL LITERATURE NEEDED

1. Planning the Electric Water System and Plumbing for Your Farmstead, Miscellaneous Publication No. 674, REA, USDA. (Available to electric co-ops from REA without charge.)

2. Your Farmhouse...Planning the Bathroom, Miscellaneous Publication No. 638, USDA. (Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 10 cents.)

3. Simple Plumbing Repairs in the Home, Farmers' Bulletin No. 1460, USDA. (Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 5 cents.)

4. Farm Plumbing, Farmers' Bulletin No. 1426, USDA. (Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 10 cents.)

5. Sewage and Garbage Disposal on the Farm, Farmers' Bulletin No. 1950, USDA. (Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 10 cents.)

6. Safe Water For the Farm, Farmers' Bulletin No. 1978, USDA. (Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.)

7. Concrete Structures for Farm Water Supply and Sewage Disposal, Portland Cement Association, 33 West Grand Avenue, Chicago 10, Illinois. (No Charge.)

8. A Practical Course in Concrete, by Henry Giese, Portland Cement Association, 33 West Grand Avenue, Chicago 10, Illinois. (No Charge.)

9. Publications on water supplies, plumbing, and sewage disposal from the state agricultural college.

10. Publications on water supplies, plumbing, and sewage disposal from the state health department.

SUMMARY OF USEFUL TECHNICAL DATA

1 cu. ft. of water weighs 62.4 lbs.
1 cu. ft. = 7.48 U.S. gal.
1 U.S. gal. of water weighs 8.34 lbs.
1 U.S. gal. = 231 cu. in. = .134 cu. ft.
1 barrel = 31.5 U.S. gal.
Ft. of head x .434 = lbs. per sq. in.
1 lb. per sq. in. = 2.31 ft. of head.
1 kwh = 746 watts = 33,000 foot-pounds per minute
450 gal. per min. = 1 acre-inch per hr. (approx.)
1 acre-inch = 3,630 cu. ft. = 27,154 gal. = 1/12 acre-foot.

$$\text{HP required} = \frac{\text{Cap. in gal. per min. X wt. per gal. X total head in ft.}}{\text{33,000 X overall efficiency}}$$

Total head = Static head + suction head + pressure head

FARM WATER AND PLUMBING SYSTEMS

A complete water and plumbing system on a farm consists of several different units. Rarely will an installation include all of the possible units, and some of the possible units will occur only infrequently. The following are the units most likely to be encountered:

1. Pump
2. Motor
3. Automatic motor switch
4. Water storage tank
5. Automatic air volume control
6. Safety pressure release
7. Water piping
8. Water softener
9. Water heater
10. Kitchen sink
11. Lavatory
12. Water closet
13. Bath tub
14. Shower
15. Laundry tubs
16. Fixture drains
17. Soil or waste stack (vent and vertical sewage disposal pipe)
18. House drain
19. Sewage disposal means
20. Grease trap
21. Dairy water heater
22. Watering troughs
23. Individual livestock drinking cups
24. Lawn and garden watering equipment

Often a farmer will install only a portion of his complete system at a time. When this is done, he should be encouraged to first plan the complete system so that he may later merely add to what is already installed rather than having to replace parts of it.

Planning The System

The planning of a farm water and plumbing system may be divided into three distinct parts:

1. Determining for what water is to be used, and where it is to be used.
2. Selecting materials and equipment to suit the needs of the particular farm.
3. Determining the layout of materials and equipment to best serve the needs.

Determining the "What For" and the "Where"

This important part of the planning is often taken for granted and neglected. Many farm water systems are not doing their best jobs on farms merely because the systems were bought and installed without first figuring out what they were expected to do.

This part of the planning is part of the farmer's management of his farm. It is his responsibility, but he usually needs help in thinking it through. Most farmers are putting in the first water systems that have ever been installed on their farms. Any running water at all, anywhere, is better than what they had before. If they have not been helped in their planning, they may not realize until some time after the installations are made that they could have had much better systems if more complete consideration had been given to the "what for" and the "where" before materials and equipment were selected and the layouts of the systems made.

Common uses of water that are involved in this phase of the planning include:

1. Kitchen sink
2. Bathroom
3. Laundry
4. Farm workers' washing and toilet facilities
5. Lawn watering
6. Garden watering
7. Automobile and machinery washing
8. Vegetable washing
9. Milk utensil cleaning
10. Milk house uses
11. Poultry watering
12. Livestock watering troughs
13. Drinking cups for livestock
14. Cleaning floors
15. Farm shop uses

Selecting Materials and Equipment

No water and plumbing system will do its best job unless the materials and equipment are selected to fit the individual farm situation. Since the farmer is buying the system, he should be well enough informed to judge whether the materials and equipment being offered him best fit his needs.

In addition to the selection of fixtures, this involves the selection of a great deal of other equipment. The pump must fit the well, the pressure conditions and the capacity requirements. The pipes must be sized so that the water reaches each outlet without excessive pressure

drop due to friction. It is usually good practice to provide piping which will allow the full capacity of the pump to be delivered at each major building with not more than 5 pounds of pressure drop from friction. For uses such as garden watering which involve long continued use of water the equipment should deliver water at a rate that will cause the pump to run continuously rather than start and stop frequently. Float controls in stock tanks are a time and labor saver. Frost-proof hydrants are a protection against freezing.

Most farmers have in the back of their minds that their new water systems are going to give them some fire protection. Many of them over-estimate this value. At best, the water that will be furnished by the ordinary water system pump will do little more than put out a fire just as it is getting started or protect other buildings from catching if one building is already burning. But even these values are dependent on a good stream of water from a garden hose. Too often the farmer does not realize that the piping between his pump and the place where the hose is connected is as important in this as is the pump itself. It is not at all uncommon to see hoses which will hardly throw streams of water to the roofs of buildings even though the pumps are adequate for the size of hose being used.

The selection of materials and equipment should always anticipate future extensions of the system. This will eliminate the need for replacement of parts when extensions are made or, what is more common, inefficient extensions.

Determining the Layout

The layout of a water and plumbing system is just as important to its best operation as is the layout of wires in a wiring system. Short, straight pipes provide best water flow with the least trouble. The location of the pump is usually determined by the source of water, but where there is a choice a location nearest the center of the load on the system will provide better service with smaller pipes. All pipes should be placed with an eye to future extensions and provided with plugged openings for the connection of extensions.

Fixtures should be placed for most convenient and efficient use even though this may require a little additional piping expense at the time of installation.

Careful planning of the layout of sewage and waste disposal equipment is especially important. Improper handling of sewage and other wastes can create fly breeding places, develop odors, contaminate food or water, and create other hazards.

Health authorities are particularly interested in proper protection of water supplies and proper handling of sewage and other wastes.

Well Protection

In some parts of the country, most farm wells are contaminated with various colon bacilli. In all parts of the country many wells are contaminated. The source of these bacilli may be either men or animals, but, regardless of their source, their presence shows that undesirable waste materials are entering the wells. Absence of disease in persons drinking water from these wells is due to the fact that the men or animals whose waste products enter the wells are not carriers of disease organisms so that only harmless bacilli get into the water, or that the persons drinking the water have developed immunity to the diseases. Such wells are health hazards. Farmers should be urged to protect their wells from contamination before installing electric pumps. Many ordinances and regulations require such protection before fluid milk can be sold by the farmer or before milk of the higher grades can be sold. All state health departments and many state colleges have printed recommendations on well protection.

Contamination enters wells from two sources -- (1) surface material including surface water, and (2) subsurface seepage.

Surface material should be excluded by grading around the well so that all surface drainage is away from it, and by covering the well with a carefully built concrete curb and watertight seal around the pump pipe. No pump should be placed in a pit over the well unless good drainage for the pit is provided and the floor of the pit is sealed so that no water can leak from it into the well.

Subsurface seepage is a more complex problem. It may be of local origin in which case it is likely through the upper layers of the soil. As protection against this local seepage, the area for 100 feet or more around the well should be kept free of contaminating wastes. Barnyards, chicken yards, etc., should be downgrade from the well, and the well should be cased watertight for at least 10 feet below the surface of the ground.

Contamination which enters the ground water may travel in this water and make wells long distances, in some cases even miles, from the source of the contamination unfit for supplying drinking water. Contamination of this sort usually is determined only after surface or shallow subsurface contamination is eliminated by proper grading, curbing, and casing of the well. The cure is to eliminate the source of the contamination or to drill a new well which taps another source of underground water. Tracing these sources of contamination may be difficult. It is usually done by placing dyes in possible sources and seeing if the color appears in the water in the well. Cesspools are rather common sources of contamination of the underground water. Their use can be justified only in very rare and unusual cases.

Most health officials have facilities for testing well water for purity or have access to such facilities.

Health authorities are glad to recommend simple methods of disinfecting contaminated wells.

It is good practice to disinfect every well before the water is first used, and after every time that the cover is removed or the pipe drawn from the well. Taste, odor, or color of the water are not adequate indicators of its freedom from disease organisms.

In general, deep wells are safer sources of water than shallow wells.

Water Systems

The term "Water System" as used by the commercial trades means the "package" of units consisting of motor, pump, storage tank, and air and electric controls for this "package", although some "systems" are sold minus the storage tank, and a few minus the air volume control.

Practically all electric water systems fall within three classifications: (1) gravity, (2) hydropneumatic, and (3) pneumatic.

Gravity Systems

As the name implies, a gravity system is one in which the water flows by gravity through the pipes to the place where it is used. Such systems are seldom used if electricity is available when the installation is first made, although many of them are later converted satisfactorily to electric operation. In a gravity system, the pump pumps the water into an elevated storage tank from which it flows to the various fixtures. The pump motor may be controlled by a float actuated switch in the elevated tank. The storage tank may be located on a tower, on a hill or in the upper part of a building. Systems operated by windmills are commonly of this type. Electric systems of this type are not sold as "packages" but are assembled by the farmer.

Hydropneumatic Systems

These are the most common electric water systems. The name is derived from the fact that the storage tank contains both air and water under pressure. In loose trade terminology these systems are often incorrectly called pneumatic systems. In a system of this type, the water is pumped into an airtight storage tank compressing the air in the tank above it. It is the pressure developed by this compressed air which forces the water through the water pipes to the various fixtures. Systems of this type are sometimes, but not often, used with windmill and gas engine power.

Some hydropneumatic systems substitute a small cast iron air chamber for the storage tank. Such systems deliver only a small amount, possibly a cup, of water before the pump starts. Sometimes they are referred to as direct connected or tankless systems. Advertising claims often stress the advantage of fresh water direct from the well for these systems. This is strictly a theoretical advantage, not being an important consideration in actual use. They are somewhat cheaper in first cost because of the absence of the storage tank, but they require more frequent motor starting, using more electricity and producing greater wear. In general, the use of direct connected systems for farm purposes should be discouraged, although there are situations,

such as summer cottages, where they are subject to only limited use, where they are desirable. Also, the tankless systems which run continuously whenever a faucet is open, regardless of whether a small or large amount of water is being drawn, are satisfactory on some farms needing only a small pump.

Pneumatic Systems

Pneumatic Systems, as the name implies, are air operated systems. From an air compressor and an air storage tank, air is piped into the well where it operates a special submerged air operated pump. When a faucet is opened anywhere in the water system, the reduced pressure on the water in the pipe allows the pump to start operating. No water storage tank is used with these systems.

These systems are relatively expensive. They are little used on farms. They are appropriate for rural garages and other places where compressed air is needed for other purposes -- the one air compressor serving both the water system and the other purposes. They are also well adapted to country estates and some farms having several wells since one air compressor will serve all of the wells.

Pumps

Different manufacturers vary the design of their pumps considerably, but certain features are essential and consistent throughout all of them. Water system pumps are divided into two groups: (1) shallow well, and (2) deep well -- on the basis of the physical behavior of water, and into six types: (1) reciprocating, (2) turbine, (3) centrifugal, (4) rotary, (5) jet, and (6) pneumatic -- on the basis of their design.

Shallow Well Pumps

In general, the dividing line for determining the selection of a shallow well or a deep well pump is a depth to water of about 22 feet. A shallow well pump functions by removing the air pressure from the water inside the pump pipe. The normal atmospheric air pressure on the water in the well outside of the pump pipe then forces the water up in the pipe.

Normal atmospheric pressure at sea level is about 14.7 pounds per square inch. One foot of water exerts a pressure of about .434 pounds per square inch. Thus, if the pump were capable of removing all of the air pressure from within the pump pipe, a shallow well pump should lift water a maximum of about 33.9 feet. However, no pump is capable of removing all of the air. In practice, the practical maximum suction lifts of pumps vary from about 15 feet to 28 feet, with 22 feet being a good practical overallfigure to use. These figures are based on pressures at sea level. As elevation increases the atmospheric pressure decreases and the suction lifts of pumps correspondingly decrease. The following table gives the practical maximum suction lifts of pumps at different altitudes based on 22 feet at sea level.

Altitude Above Sea Level	Suction Lift of Pump
Sea Level	22 ft.
1,320 ft. (1/4 mile)	21 ft.
2,640 ft. (1/2 mile)	20 ft.
3,960 ft. (3/4 mile)	18 ft.
5,280 ft. (1 mile)	17 ft.
6,660 ft. (1¼ mile)	16 ft.
7,920 ft. (1½ mile)	15 ft.
10,560 ft. (2 miles)	14 ft.

Shallow well pumps are usually cheaper than deep well ones. They are entirely satisfactory in locations where the water level is never farther below the pump than has been indicated in the table above. They do not need to be located directly over the well.

Deep Well Pumps

Deep well pumps are used where the depth to water is more than 22 feet (See table under Shallow Well Pumps). They differ from shallow well

pumps in that the actual pumping mechanism is lowered into the well so that it is within 22 feet of the water. (This mechanism is usually submerged in the water). The driving mechanism (known as the pumping head) must be adapted to the depth of the well and the volume of water handled, and, for the reciprocating and turbine types, must be located directly over the well. This frequently requires the construction of a pump house or pit over the well for the protection of the machinery.

Reciprocating Pumps (Sometimes called plunger or piston type pumps)

Until about 1940, these were the most common pumps used on electric water systems for both shallow well and deep well operation. As the name implies, this type of pump consists of a piston or plunger in a cylinder (or a diaphram in a housing) together with an appropriate set of valves. Figures 1 and 2 illustrate common reciprocating pumps.

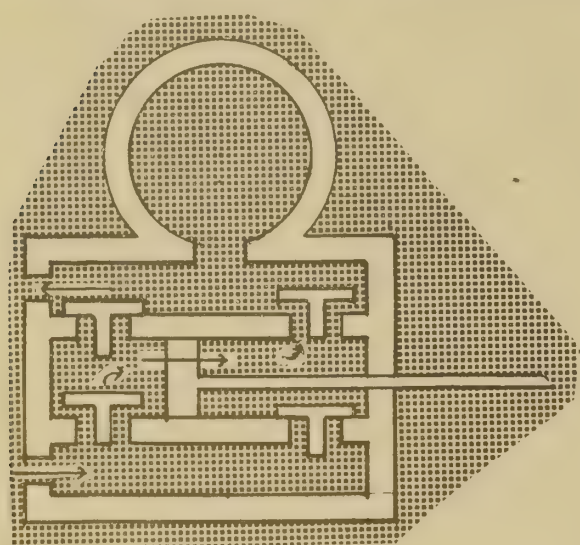


Figure 1

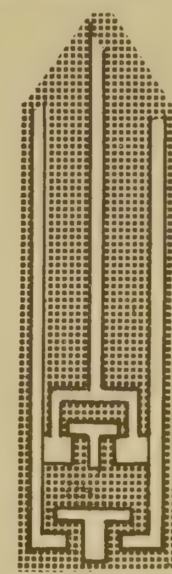


Figure 2

Figure 1 illustrates a shallow well pump which is also a double acting pump since each end of the cylinder pumps water independently of the other end. As the plunger moves to the right, water is drawn in through the lower left valve and forced out through the upper right valve. As it moves to the left, water is drawn in through the lower right valve and forced out through the upper left valve. The air chamber serves as a cushion smoothing out the flow of water from the pump. Figure 2 illustrates the cylinder of a deep well reciprocating pump. This cylinder would be lowered into the well. As the plunger moves up in the cylinder, the plunger valve closes, lifting the water above it, and water is drawn in through the foot valve. As it moves down, the foot valve closes and water is forced through the plunger valve. Double acting deep well cylinders are sometimes used, and commonly a differential cylinder is built into the pumping head to give a double acting effect to a single acting cylinder. The drop pipe below the foot valve may be of any length or may be absent, and often a strainer is attached to its lower end. The mechanical construction of the plunger and valves varies with the depth of the well for which the cylinder is built.

Turbine Pumps

Turbine pumps are built both as shallow well and deep well pumps although the smallest deep well ones are usually too large for ordinary farm water systems except for installations requiring very large quantities of water. A turbine pump functions by sweeping a series of vanes at high speed beside a shallow water channel. They are sometimes spoken of as being modified centrifugal pumps. Although there is close similarity to centrifugal pumps in their mechanical construction, the pumping action of the shallow well ones is quite different. The deep well ones use some centrifugal action in their operation.

Figure 3 illustrates a shallow well turbine pump.

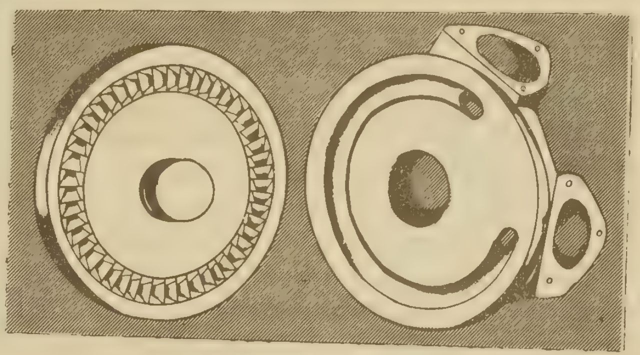


Figure 3

Turbine pumps for farm water systems are made by several manufacturers. They are particularly smooth in operation. Dirt or fine sand in the water causes the closely fitting surfaces in them to wear very rapidly. When they are used in situations where dirt or sand may be in the water they pump, they should be well protected by very fine screens. Shallow well turbines are self-priming but should not be run dry because some of them depend on water for their lubrication.

Centrifugal Pumps

Centrifugal pumps function by rotating the water within a circle. This throws the water to the outer edge of the circle where the pump outlet is located and leaves a vacuum at the enter of the circle. Figure 4 illustrates a centrifugal pump.

Figure 4

Until the development of jet pumps within recent years, centrifugal pumps were rarely used with farm water systems. They are now commonly used with jets and in some cases without jets. In general, they are adapted to handling large volumes of water at low pressures and very special designs have been necessary for them to operate at the pressures used in water systems. They are very smooth in operation, in this respect being like turbine pumps. They are not self-priming although some manufacturers are equipping them with air separation devices so that when they are once primed they can handle air with the water without losing their prime.

Rotary Pumps

Rotary pumps depend on the rotation of parts for their pumping action. They differ from turbine pumps and centrifugal pumps in that they are positive displacement pumps, in this respect being like reciprocating pumps. A positive displacement pump is one which delivers a more or less fixed amount of water with each cycle of operation regardless of the pressure against it. Their efficiency does not depend on speed.

Rotary pumps are made in several styles which at first glance may appear to have little or no resemblance to each other. A few years ago, the most common style consisted of two gears running together in a casing or housing. (See figure 5). Water is carried between the teeth on the ouside of each gear but cannot return between them because of the meshing of the teeth. The casing must fit the gears closely to prevent the leaking of water past the ends of the teeth or past the faces of the gears.

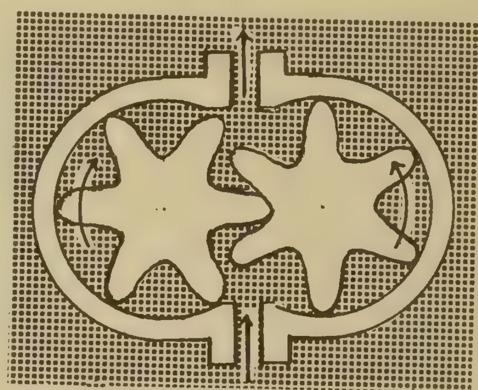


Figure 5

Another style is known as a helical rotor. (See figure 6). It has a long slender rotor with a rounded spiral rise in its exterior surface. The rotor revolves inside a stationary housing or stator which has two similarly rounded spiral depressions on its interior surface. The rotation of the rotor squeezes water, trapped in the stator depressions, continuously along the inside of the stator.

Figure 6

There are a number of other styles of rotary pumps but few of them are used in farm water systems.

Jet Pumps

Jet pumps are relatively new. They became generally known in the late 1930's and now have become a very popular type of pump. To understand their operation, it is necessary to realize that a jet pump never is used alone but always in connection with a pump of some other type. It is the combination of these two pumps that is commonly known by the trade as a "jet pump" or "ejector pump". The other pump of the combination is most commonly centrifugal, although some are turbines and

a few are reciprocating. Any shallow well pump -- reciprocating, turbine, centrifugal, or rotary -- can be converted to a "jet pump" by adding the jet pump portion of the combination. Some of the first jet pumps to appear on the market were merely attachments for any shallow well pump and their purpose was to convert the shallow well pump to a deep well pump.

Some shallow well "jet pumps" have the centrifugal pump and the jet pump built together in one casting. When pumps are made in this way, the jet part of the combination is solely for the purpose of making the combination capable of working on comparable suction lifts and against comparable pressures to other types of shallow well pumps.

Figure 7 illustrates a jet pump. Water under pressure from the "pump" outlet passes down the drive pipe and is forced at high velocity through the jet nozzle and venturi. As it passes through the venturi this jet of water draws additional water up through the foot valve and forces it up the delivery pipe to within the suction lift of the shallow well pump at the top. The jet nozzle and the venturi must be adapted to the depth of the well. Most manufacturers furnish three different combinations of nozzles and venturis for the range of depths from 20 feet to about 100 feet.

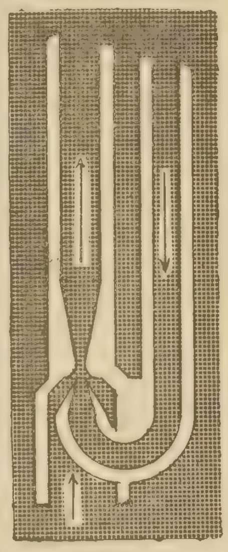


Figure 7

There are two types of deep well jets known respectively as double pipe jets and single pipe jets. The illustration in figure 7 shows a double pipe jet and this is the one used when the well is large enough to admit two pipes. The single pipe jets are used in drilled wells not large enough to admit the two pipes of the double pipe jets. They differ from the double pipe jets in that only one pipe with the entire jet assembly on the end of it is lowered into the well where the jet assembly is expanded to make a watertight seal with the well casing. The well casing itself then serves as either the drive pipe or the delivery pipe. Frequently, the single pipe jets are known as packer jets because the arrangement on the jet body which expands to make the seal with the well casing is called a packer.

Contrary to the ideas of some enthusiastic individuals, the jet pump is not a universal substitute for other types. It is a versatile pump, but there are situations where other pumps are equally satisfactory or to be preferred. Its range of superiority is in wells where the depth to water is between 22 feet and about 75 feet, particularly where it is not desirable to locate the driving mechanism directly over the well. In shallower wells, the "old-fashioned" shallow well pumps are equally satisfactory. While jet pumps are usually recommended by the manufacturers for depths to water of 120 to 150 feet and at least one of them will operate at depths to 600 feet, their efficiency of operation falls at these greater depths to such an extent that farmers are often well advised to use the "old-fashioned" reciprocating deep well pumps when depth is more than 75 feet and sometimes at even less depth.

Pneumatic Pumps

Pneumatic pumps are used only on pneumatic systems and, therefore, they are rather rare in farm water systems. Their mechanism is relatively complex. Essentially, these pumps consist of closed chambers with appropriate pipe connections and complicated systems of valves. They are submerged in the water in the well. When the pump chamber is full of water, a float actuated system of valves closes the water inlet, closes the air exhaust opening, opens the valve to the discharge pipe, and opens the valve which admits air from the air compressor. The compressed air then forces the water in the pump into the discharge pipe. Another float and valve arrangement then closes the valve which admits air from the air compressor, closes the valve in the discharge pipe, opens the air exhaust opening so that the air in the pump escapes into the well, and opens the water inlet opening so that the pump again fills with water. The pump continues to pump water into the discharge pipe as long as a faucet anywhere in the water system is open. It stops pumping when all faucets are closed so that the compressed air cannot force more water into the discharge pipe. These pumps deliver a pulsating flow of water. These pulsations are eliminated in the piping by the installation of air domes.

Motors

Split phase, capacitor, and repulsion-induction motors are all used on farm water systems. Reciprocating and rotary pumps start under full load and therefore repulsion-induction motors are most desirable with these types. Turbine and centrifugal pumps pick up their load as they gather speed and are therefore adequately equipped with capacitor motors. Reciprocating pumps are usually belt driven while the rotors in turbine, centrifugal, and rotary pumps are usually mounted directly on the motor shafts.

All farm pump motors should be equipped with automatic or manually reset overload protection.

Automatic Motor Switches

Electric "water systems" commonly come equipped with automatic switches for stopping and starting the motors. These switches are operated by the pressures in the storage tanks but are usually mounted on the frames of the pumps. If the storage tank and pump are located side by side, a small copper tube may lead from the tank to this switch. Perhaps, more commonly the switch is connected to the delivery pipe from the pump by a small copper tube so that it receives the pressure of the storage tank indirectly through the delivery pipe. The switch is usually adjusted so that it turns the motor on when the pressure in the tank decreases to 20 pounds and turns it off when the pressure

reaches 40 pounds. Some of them are adjustable so that this range in pressures can be changed but it is unusual that this is not a satisfactory range. Figure 8 illustrates an automatic switch.

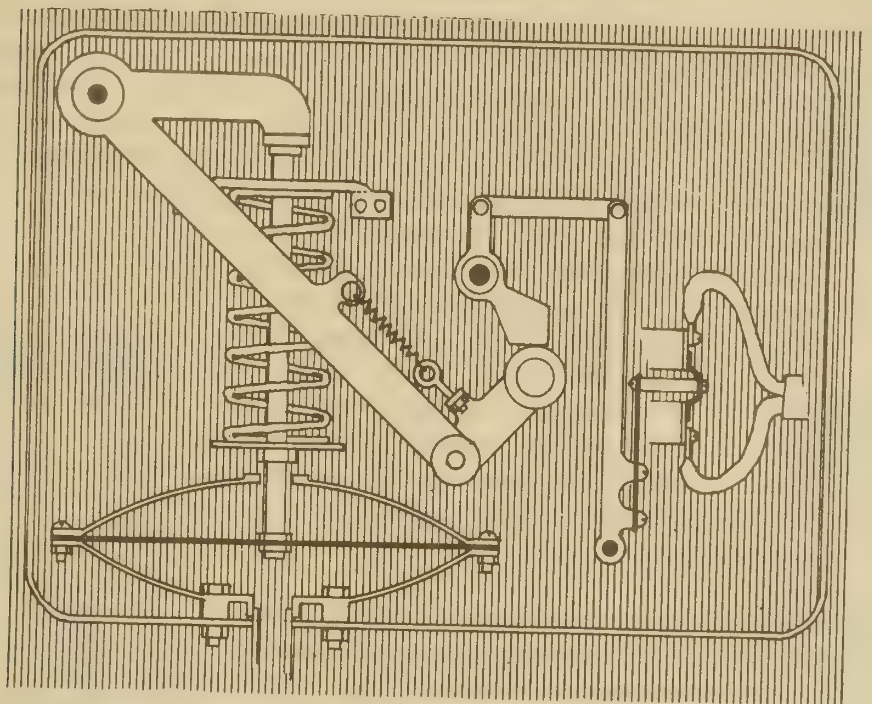


Figure 8

Water Storage Tanks

Hydropneumatic water storage tanks come in a wide variety of sizes varying from about 12 gallons to several hundred gallons capacity. As a general rule, the 42 gallon size is the smallest that should be recommended for general farm use. If there is a dairy herd of 10 or more cows or if the water is to be used for garden watering, at least an 80-gallon tank should be used. Small pumps pumping from wells that supply water slowly need larger tanks than adequate wells with large pumps.

Water is pumped into the bottom of the tank and as it fills the tank it compresses the air above it. It is this compressed air that furnishes the pressure to force the water through the pipes of the water system. Thus the entire capacity of the tank is not available for water storage. The active water supply is usually about 1/5 of the volume of the tank, or a 42-gallon tank will furnish about 8 gallons of water after the pump stops before the pump starts again. The quantity of air in the tank is maintained by the air volume control.

Either a gate or globe valve should be placed in the outlet of the tank so that the water may be shut off when, for any reason, it is necessary to make a repair anywhere in the water piping system, and, unless the tank is very small, a gate valve or a check valve should be between the pump and the tank so the pump can be repaired without draining the tank.

The main purpose of the tank is often misunderstood. Since the pump starts and stops automatically there is little need to keep a supply of water under pressure. The amount of water stored in these tanks is so small that it would be of little significance if there was an extended period of time during which the pump was out of operation. Also, the first sign that the family usually has that the pump is not running is failure of water to flow from a faucet. The main purpose is to prevent frequent starts and stops of the pump, thus reducing wear and tear. Without the tank, the pump starts and stops each time a little water is used, but even more important, it starts and stops frequently while water is being drawn from a faucet if the water is flowing slower than the pump pumps. By reducing the number of starts and stops, the life of the machinery is prolonged.

All pumps except centrifugal (and centrifugal jets) should be protected by a safety pressure release from excessively high pressures. Centrifugal pumps are not capable of producing dangerously high pressures even when the switch fails and the pump continues to run, and therefore they do not need this protection. The pressure release valve (illustrated in figure 9) is usually installed between the pump and the storage tank. It must be placed so that no valve can isolate it from the pump.

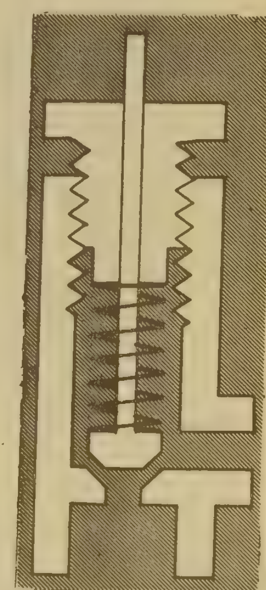


Figure 9

Automatic Air Volume Controls

At all times, water has a certain amount of air dissolved (not mixed) in it. When air pressure on water is increased, as it is when water is stored in a hydropneumatic tank, more air dissolves in the water. This means that continually the air in the hydropneumatic tank is passing out with the water as it is withdrawn. If the system is to continue to operate properly it must be equipped to replace this lost air. This is done in several ways.

Deep well reciprocating pumps are usually equipped with a separate cylinder which pumps air with the water into the tank whenever the pump runs. This provides an excess of air. The surplus air is then

released from the tank by a valve controlled by a float in the tank. Figure 10 is a schematic illustration of this type of air volume control.

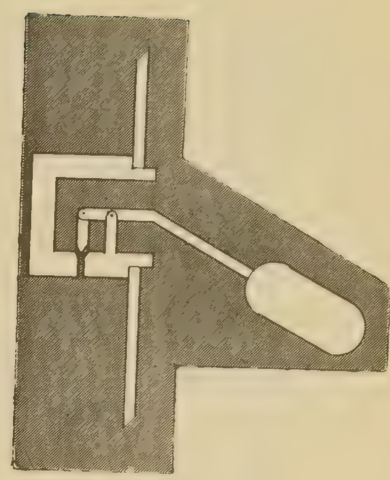


Figure 10

A shallow well reciprocating pump usually has an air volume control on the side of the tank which is connected by a small copper tube to an opening in the suction side of the pump. A float controlled valve in the air volume control is opened when the water in the tank rises to a certain level and the pump then sucks air through this valve and the copper tube into the pump cylinder. The plunger in the pump then forces the air into the tank with the water. When the tank has the correct amount of air for best operation the water does not rise high enough to cause the float to open the small valve and no air is then pumped into the tank. This type of air volume control is illustrated schematically in figure 11. This type is also used with rotary pumps, turbine pumps, and some of those jet pumps (both deep well and shallow well) which can handle a little air without losing their prime.

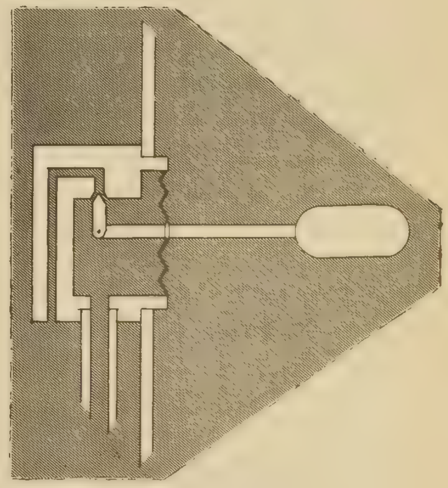


Figure 11

A third type of air volume control is a small highly specialized air pump. It frequently is called an aspirator. The two types of controls described above were merely float controlled valves, and the air pumping was done by the same pump that pumped the water. When jet pumps first became popular they were not capable of handling air without losing their prime so it was necessary to use air volume controls that did not admit air to the water pump. The aspirator type was developed to meet this need.

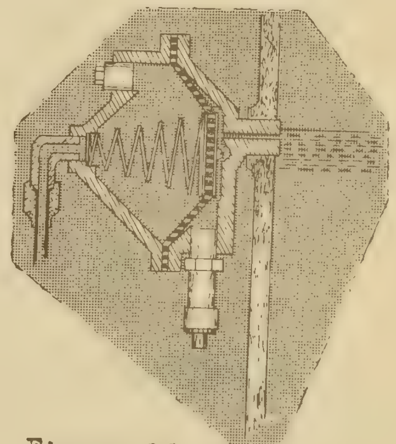


Figure 12

The most common of the aspirator type of controls consists of a small diaphram in a housing with the space on one side of the diaphram connected to the suction side of the water pump by a small copper tube and the space on the other side connected through a very small orifice to the storage tank. A Schrader valve similar to the valve in an automobile tire innertube or a ball valve is inserted between the outside air and the space on the side of the diaphram toward the tank. The copper tube to the water pump and the space in the aspirator to which it is connected are completely filled with water. An air volume control of this type is shown in figure 12.

When the water pump is not running and the tank pressure equalizes through the pump there will be equal pressure on both sides of the diaphram in the air volume control. When the pump starts the pressure in the tank and through the orifice into one side of the control changes very little while the pressure on the other side of the control diaphram drops suddenly due to the suction of the pump. This causes the diaphram to move suddenly. If the water is low enough in the tank so that air covers the orifice into the air volume control this sudden motion of the diaphram will draw air through the orifice. When the pump stops and the pressure again equalizes on both sides of the diaphram, the diaphram will return to its original position returning the same air to the tank. If, when the pump starts, water covers the orifice into the control, the movement of the diaphram will tend to draw in water from the tank. However, the orifice is too small to allow much water to flow through it quickly. This causes air to be drawn into the control through the Schrader or ball valve. Then when the pump stops, this fresh air will be forced through the orifice into the tank. In this manner this type of control adds a small amount of new air to the tank each time the pump stops if the water in the tank stands at a level which covers the orifice to the control.

Some controls of this type use floating valves instead of diaphrams. Others use plungers.

In addition to the three general types of air volume controls described above there are several others that are used occasionally.

Water Piping

The rate at which water will flow from a pipe depends on the pressure behind the water, the elevation to which this pressure raises it, the roughness of the interior surface of the pipe, the size of the pipe, the length of the pipe, and the number of elbows, tees, and valves in the pipe.

Height That Water Is Raised

Each foot of water develops a pressure of about .434 pounds. Thus 20 pounds of pressure in the storage tank will raise water a maximum of 46.2 feet. In calculating the flow of water through pipes, it is necessary to subtract the pressure resulting from the height to which the water is raised above the storage tank or pump from the storage tank or pump pressure to determine the effective pressure causing the water to flow.

Roughness of Interior Pipe Surface

There is friction between the water flowing through a pipe and the wall of the pipe. Pressure is required to overcome this friction. The rate of flow of water through a pipe becomes constant at the

point where the pressure required to overcome this friction equals the available pressure. Common pipes are either steel or copper. Of these two, copper pipe is the smoother and, therefore, smaller copper pipe than steel pipe will deliver water at a specified rate. However, the difference is not as great as many people suppose. As pipe gets older, the interior surface becomes rougher. For this reason, estimates of the rate of delivery must be based on the assumption of new pipe at the time of installation or the average condition of pipe after it has been in use a certain number of years -- say, 10, 15, or 25. This causes considerable variation in estimates unless this condition is specified. Tables of pipe friction are included under the discussion of pipe fittings and size and length of pipe.

Pipe Fittings and Size and Length of Pipe

Most calculations of the amount of water that will flow through a pipe are based on tables of water friction in the different sizes of pipes. Some calculations are based on new pipe. Installations based on these calculations will not deliver the calculated quantities after the pipes become old. Other calculations are based on average pipe of a specified age, such as 10 years, 15 years, or 25 years. Such installations will deliver more than the calculated quantities of water when the installations are new. The tables given below are based on ordinary steel pipe such as may be present after 12 to 15 years of service and on new copper pipe. Copper pipe does not usually roughen as much with age as does steel pipe. For new smooth steel pipe, the friction will be about 75 percent of that given, and for 25 year old pipe, it will be about 20 percent greater. Tables of this type may be given either in terms of loss of pressure in pounds per square inch or in terms of "loss of head" in feet. Conversion from one method to the other is easy if it is remembered that one pound of pressure equals 2.31 feet of head (depth of water) or one foot of head equals .434 pounds of pressure. These tables are most commonly given in terms of "loss of head" so that is the terminology used below.

FRICTION OF WATER IN COPPER TUBING

Loss of Head in Feet* Due to Friction Per 100 Feet of Smooth Pipe
(Type L Copper Tubing)**

Gallons Per Min.	3/8" Tubing	1/2" Tubing	3/4" Tubing	1" Tubing	1-1/4" Tubing	1-1/2" Tubing	2" Tubing	2-1/2" Tubing	3" Tubing
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
1	8.1	2.8	.46						
2	27.	8.8	1.5	.42					
3	53.	18.	3.0	.86	.32				
4	88.	30.	5.1	1.4	.52	.23			
5	130.	43.	7.6	2.1	.79	.35			
6	180.	60.	10.	2.9	1.1	.48			
7	230.	78.	14.	3.8	1.4	.62			
8		98.	17.	4.8	1.8	.79			
9		120.	21.	6.0	2.2	.97	.26		
10		150.	25.	7.3	2.7	1.2	.31		
15			51.	15.	5.5	2.5	.62		
20			85.	25.	9.0	3.9	1.0	.36	
25			125.	37.	13.	6.0	1.6	.53	
30			170.	49.	19.	8.1	2.1	.74	.30
35			230.	63.	25.	11.	2.8	.96	.40
40				79.	30.	13.	3.5	1.2	.51
45				98.	37.	16.	4.3	1.5	.64
50				120.	45.	20.	5.3	1.8	.78

*From Chart in Figure 7 of Report BMS66, National Bureau of Standards.

**Data is for new copper tubing with recessed soldered joints. It may also be applied to any correspondingly smooth pipe such as brass pipe.

FRICTION OF WATER IN IRON OR STEEL PIPE
Loss of Head in Feet* Due to Friction Per 100 Feet of Fairly Rough Pipe**

Gallons Per Min.	3/8" Pipe	1/2" Pipe	3/4" Pipe	1" Pipe	1¼" Pipe	1½" Pipe	2" Pipe	2½" Pipe	3" Pipe
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
1	17.	4.3	.59						
2	64.	16.	2.2	.51					
3	140.	35.	4.6	1.1	.40	.15			
4		60.	8.1	1.9	.70	.27			
5		92.	13.	3.0	1.0	.41			
6		130.	18.	4.2	1.5	.58			
7		175.	25.	5.8	2.0	.79			
8		230.	31.	7.4	2.4	1.0	.25		
9			38.	9.3	3.1	1.2	.31		
10			48.	11.	3.9	1.6	.39		
15			100.	26.	8.5	3.3	.85	.28	
20			180.	43.	15.	6.0	1.5	.48	
25				67.	23.	9.0	2.3	.74	.31
30				97.	32.	13.	3.1	1.1	.44
35				130.	43.	17.	4.2	1.4	.60
40				160.	55.	22.	5.3	1.8	.75
45				220.	69.	28.	6.9	2.3	.96
50					86.	35.	8.6	2.8	1.2

*From chart in Fig. 9 of Report BMS66, National Bureau of Standards.
**Fairly Rough Pipe will approximate in many installations the condition of ordinary iron or steel pipe after it has been in use 12 to 15 years.

Friction of water in an elbow, tee, globe valve or faucet may be assumed to equal that in 10 feet of straight pipe. Friction in gate valves, couplings, and unions may be neglected. A more exact evaluation of friction in these fittings is given below, but this assumption is accurate enough for most applications. Faucets are essentially globe valves as far as friction is concerned.

ALLOWANCE IN EQUIVALENT LENGTH OF PIPE FOR FRICTION LOSS IN VALVES AND THREADED FITTINGS*

Size of Fitting Inches	90° Elbow Feet	45° Elbow Feet	90° Tee Feet	Coupling or Straight Run of Tee Feet	Gate Valve Feet	Globe Valve Feet	Angle Valve Feet
3/8	1	0.6	1.5	0.3	0.2	8	4
1/2	2	1.2	3	0.6	0.4	15	8
3/4	2.5	1.5	4	0.8	0.5	20	12
1	3	1.8	5	0.9	0.6	25	15
1¼	4	2.4	6	1.2	0.8	35	18
1½	5	3	7	1.5	1.0	45	22
2	7	4	10	2	1.3	55	28
2½	8	5	12	2.5	1.6	65	34
3	10	6	15	3	2	80	40

*From Table 604-111 (b) of Report BMS66, National Bureau of Standards

The use of friction tables can best be explained by examples.

Example No. 1

Pressure in the storage tank varies from 20 pounds to 40 pounds. How fast will water flow into a stock tank on the same level as the storage tank through 142 feet of 3/4 inch steel pipe, three 90 degree elbows, and one faucet?

Calculation:

Average pressure in tank $\frac{20 + 40}{2}$ = 30 pounds

30 pounds of pressure = 30 x 2.31 or 69.3 ft. of head to overcome friction

Three 3/4" 90° elbows = 3 x 10 or 30 ft. pipe. (friction equivalent)

One 3/4" faucet = 10 ft. pipe.

Pipe (3/4") = 142 ft.

Equivalent 3/4" pipe = 182 ft.

Ft. of head to be lost through friction per 100 ft. of pipe $\left(\frac{69.3 \times 100}{182}\right) = 38.07$ ft.

Flow into stock tank (See Friction Table for Gal. per Min. through 3/4" pipe with 38.07 ft. friction) = 9 gal. per min.

Example No. 2

Pressure in the storage tank varies from 20 pounds to 40 pounds. What size steel pipe shall be used to produce a flow of 5 gallons per minute from the bathroom lavatory faucet if there will be 40 feet of pipe, 3 elbows, and one globe valve in the pipe line, and the lavatory faucet is 10 feet above the storage tank?

Calculation:

Average pressure in tank $\left(\frac{20 + 40}{2}\right)$ = 30 pounds

30 pounds pressure = 30 x 2.31 =		69.3 ft. of head
Feet of head required to lift water to faucet	=	10.
Feet of head available to overcome friction		59.3
Friction in three elbows	=	30 ft. of pipe
Friction in one globe valve	=	10 ft. of pipe
Friction in 1 faucet	=	10 ft. of pipe
Pipe	=	40 ft.
Friction equivalent	=	90 ft. of pipe

Equivalent ft. of head available per 100 ft. of pipe

$\left(\frac{59.3}{90} \times 100\right) = 65.9$

Size of pipe necessary (See Friction Table for 5 gal. per min. and 65.9 ft. of head) = 3/4"

Note: 1/2" pipe would furnish a little over 4 gal. per min. in this installation since at 4 gal. per min. only 60 feet of friction head would be used. Since 1/2" pipe will not furnish the required quantity, 3/4" pipe must be used although it will furnish over 10 gal. per min, with 65.9 feet of head friction loss.

Example No. 3

Pressure in the storage tank varies from 20 pounds to 40 pounds. A 1" steel pipe leads from the storage tank and supplies water for the kitchen sink, the bathtub, and the bathroom lavatory. The pipe to the kitchen sink branches off through a tee in the 1" pipe 42 feet from the storage tank and the 1" pipe continues on to serve the bathroom fixtures. There are three elbows in the 1" pipe before it reaches the branch to the sink. From the tee in the 1" pipe to the faucet at the kitchen sink there is 33 feet of pipe with four elbows. The sink faucet is 15 feet above the storage tank. What size pipe will be necessary to the kitchen sink in order that 5 gal. per min. will flow from the sink faucet when 10. gal. per min. are flowing into the bathtub and 5 gal. per min. are flowing into the lavatory?

Calculation:

Average pressure in tank $\left(\frac{20 + 40}{2}\right.$ = 30 pounds

30 pounds pressure = 30 x 2.31 = 69.3 ft. of head

Feet of head required to lift water to sink faucet	= 15.
Feet of head available to overcome friction	= 54.3
Friction in 3 elbows in 1" pipe	= 30 ft. of pipe
1" Pipe	= 42 ft. of pipe
Friction equivalent	= 72 ft. of pipe

Loss in head of 20 gal. per min. through 1" pipe (from friction table) $\left(\frac{72}{100} \times 43\right) = 30.96$ ft.

Head remaining to overcome friction in pipe to sink (54.3 - 30.96) = 23.34 ft. of head

Friction in 4 elbows and 1 tee	= 50 ft. of pipe
Friction in faucet at sink	= 10 ft.
Pipe to sink	= 33 ft.
Friction equivalent of pipe to sink	93 ft.

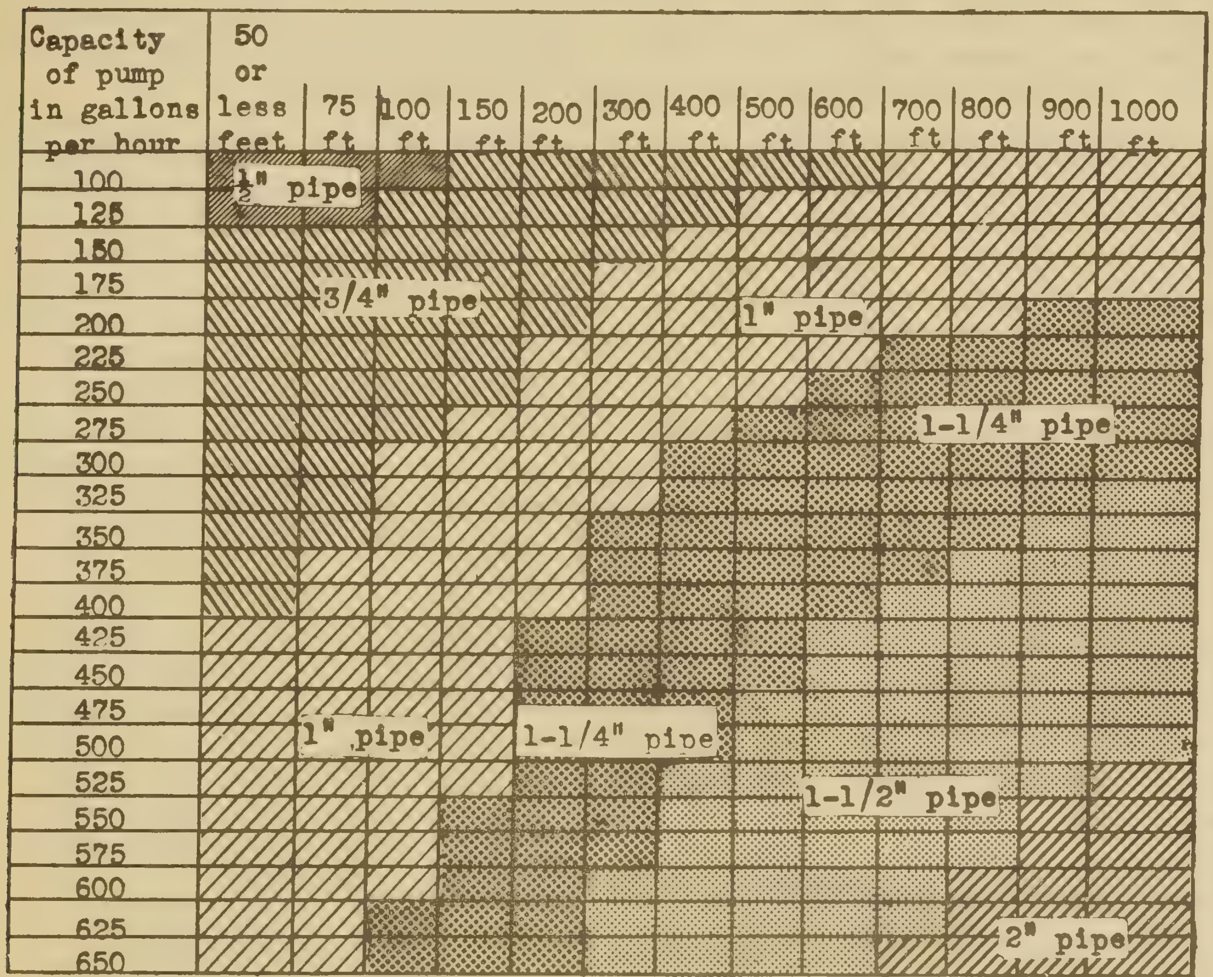
Equivalent feet of head available per 100 ft. of pipe

$\left(\frac{23.34}{93} \times 100\right) = 25.1$

Size of pipe necessary (See Friction Table for 5 gal. per min. and 25.1 feet of head) = 3/4"

Note: 1/2" pipe would require 92 ft. of head to overcome the friction. Only 25.1 feet is available. Therefore 1/2" pipe would not supply the needed water so larger pipe must be used. 3/4" pipe would do it with 13 feet available to overcome friction. The actual amount supplied through the 3/4" pipe will be about 7 gal. per min., as 7 gal. per min. would require 25 ft. of head.

The tables given above furnish data from which correct pipe sizes can be calculated for practically all situations. However, in many situations conditions are near enough alike so that we can use the data from these tables to prepare charts that are much simpler to use. In most situations the pipe from the pump to the main buildings should be large enough so that the full capacity of the pump is available with not more than 5 pounds of pressure loss from friction. The chart shown below gives the correct pipe sizes for these situations.



Here is an example of how to use the chart: Suppose a farmer s pump has a capacity of 425 gallons per hour and there are 300 feet of pipe from the pump to his barn. A little more than half-way down the column headed "Capacity of pump in gallons per hour" you will find the figure "425". Read across the chart from "425" until you are in the column directly under "300 ft". You will notice that you are now in a part of the chart labeled "1-1/4" pipe". This means that in this situation 1-1/4 inch pipe would deliver the full capacity of this pump at the barn with not more than 5 pounds of pressure loss from pipe friction.

Water Softeners

Many farm families are accustomed to using hard well water for drinking, and soft cistern water for washing. They want to continue to have both hard and soft water available after the electric water system is installed. This can frequently be done by installing separate water systems for the well and for the cistern. If the well is adequate, it can also be done by discarding the cistern and placing a water softener in the well water system in such a way that water to the faucets that are to supply soft water will pass through the softener. This is frequently cheaper than installing a separate system for the cistern water.

Water softeners are simple machines and the cost of operation is small. The simplest ones consist of a tank similar to a range boiler in appearance filled with a special sand known as Zeolite. As water passes through the Zeolite, the various calcium and magnesium compounds that make the water hard are changed to sodium compounds which have no significant effect in the water. After a period of operation, the Zeolite will do no more softening. Common salt is then placed in the softener and washed slowly through the Zeolite and discarded. This removes the calcium and magnesium from the Zeolite and replaces the sodium in it, leaving the Zeolite ready to soften water again. More expensive softeners have a second tank which is filed with salt brine. These softeners are regenerated by opening certain valves and closing others so that some of the brine is forced through the Zeolite.

Both natural and synthetic Zeolites are available. They vary in their composition, some of the synthetic ones being capable of removing iron and other compounds as well as calcium and magnesium compounds.

Distributors handling water softeners will analyze water samples and recommend the type of Zeolite most suitable to the particular water. A water analysis should be made before a softener is bought to determine the amount of hardness present and the type of Zeolite needed.

Hardness in water is commonly measured in terms of grains per gallon. Hard water may be expected to have from 5 to 50 grains of hardness per gallon. The softener selected should be of such capacity that it will not need regeneration oftener than once a week - a size requiring regeneration only once every two weeks or at longer periods is still better.

One well-known manufacturer gives the following capacities for his softeners between regenerations:

For Softener Only

Size of Tank Diameter	Height	Flow Rate G.P.M.	Wt. of Zeolite Pounds	Grains of Hardness Removed
11"	66"	6	55	12,000
13"	66"	8	110	24,000
17"	66"	14	165	36,000
19"	66"	18	220	48,000
23"	66"	26	330	72,000
25"	66"	32	440	96,000

For Combination Softener and Iron Remover

Size of Tank Diameter	Height	Flow Rate G.P.M.	Wt. of Zeolite Pounds	Grains of Hardness Removed
11"	66"	6	50	8,000
13"	66"	8	100	16,000
17"	66"	14	150	24,000
19"	66"	18	200	32,000
23"	66"	26	300	48,000
25"	66"	32	400	64,000

Based on the above two tables, the following two tables give the amount of water that may be softened between regenerations:

For Softener Only

Size of Tank		Grains of Hardness per Gallon									
		5	10	15	20	25	30	35	40	45	50
		Gallons Between Regenerations									
Diameter	Height	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.
11"	66"	2400	1200	800	600	480	400				
13"	66"	4800	2400	1600	1200	960	800	685	600	533	480
17"	66"	7200	3600	2400	1800	1440	1200	1028	900	800	720
19"	66"	9600	4800	3200	2400	1920	1600	1370	1200	1066	960
23"	66"	14400	7200	4800	3600	2880	2400	2056	1800	1600	1440
25"	66"	19200	9600	6400	4800	3840	3200	2750	2400	2132	1920

For Combination Softener and Iron Remover

Size of Tank		Grains of Hardness per Gallon									
		5	10	15	20	25	30	35	40	45	50
		Gallons Between Regenerations									
Diameter	Height	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.
11"	66"	1600	800	533	400						
13"	66"	3200	1600	1066	800	640	533	457	400		
17"	66"	4800	2400	1600	1200	960	800	685	600	533	480
19"	66"	6400	3200	2132	1600	1280	1066	914	800	711	640
23"	66"	9600	4800	3200	2400	1920	1600	1370	1200	1066	960
25"	66"	12800	6400	4264	3200	2560	2132	1828	1600	1422	1280

Special softeners and conditioners are made to meet many special conditions. They contain special chemicals and can be obtained to neutralize acid, remove undesirable tastes and odors, and to correct several other undesirable conditions.

Water Heaters

Water may be heated by an electric water heater, by a range boiler and a water front or back in the kitchen range, or by several other means. Ordinarily only electric and gas heaters are thermostatically controlled so that they keep hot water at the right temperature available continuously without close attention.

Electric storage water heaters are made in several sizes. The 30-gallon size is very common. However, larger sizes are sometimes desirable. They make a larger quantity of hot water available for laundry purposes and other needs for considerable hot water, and may be necessary when automatic washers are used. An increase to a larger size of water heater can be expected to increase the consumption of electricity about one Kwh each month per gallon of increased capacity because of greater standby losses.

Some electric heaters are equipped with one thermostat and one heating element while others have two thermostats and two heating elements. The latter are to be preferred because of the quick recovery that they provide when a large quantity of hot water is used, and because of the lighter load they put on wiring and transformers in regular daily use. When only a small amount of water is drawn from the heater, hot water remains in the top of the tank and only the lower element comes on to heat the cold water that has come in. When larger quantities are drawn so that the whole tank is cooled, the upper heating element comes on.

On some heaters, the thermostats are independent of each other while on others they are inter-connected so that only one heating element may be heating at any one time. The inter-connected thermostats are used where it is desirable to limit the load on the wiring system or transformer to one element.

Most manufacturers make at least some of their regular runs of heaters to meet NEMA standards for heating element sizes. On most heaters, elements of different sizes are inter-changeable so that larger or smaller ones may be substituted for each other. On all twin-element heaters the large one is in the top of the tank to give quick recovery in cases of emergency use of large quantities of hot water while the smaller element in the bottom of the tank does the regular water heating. The following two tables give the NEMA standards for heating element sizes:

For Single-Element Heaters

Tank Size in Gallons		Wattage Rating
Range	Nominal	
30 to 35	30	1,500
35 to 45	40	2,000
45 to 55	52	2,500
55 to 70	66	3,000
70 to 90	80-90	3,000

For Twin-Element Heaters

Tank Size in Gallons		Wattage Rating	
Range	Nominal	Upper Element	Lower Element
30 to 35	30	1,000	600
35 to 45	40	1,250	750
45 to 55	52	1,500	1,000
55 to 70	66	2,000	1,250
70 to 90	80-90	2,500	1,500
90 to 115	110	3,000	2,000
115 to 135	120	4,000	2,500
135 to 175	140	4,000	3,000

Thermostats on twin-element heaters are usually incorrectly adjusted when the heaters are installed. Few people understand their correct adjustment. This causes the heater to add much more to the demand on the transformer and to the peak load of the electric system, with no additional benefit to the consumer.

When the thermostats on twin-element heaters are correctly adjusted the upper one (controlling the larger element) is set from 5 degrees to 10 degrees lower than the lower one. If this differential is not maintained much of the regular heating will be done by the large upper element. If this differential is maintained the large element may not come on more than two or three times a week and then only when there have been unusually large uses of hot water.

There is little agreement among various authorities as to the best temperatures for water in an electric heater. Even the manufacturers of automatic washing machines differ over a range of about 140° F to 180° F in their recommendations of the temperature of the hot water that should enter their machines. One significant fact that should not be overlooked, although it may not be most important in any particular case, is that most well water is hard water. As temperatures increase, more scale from hard water is deposited on the inside of heaters and hot water pipes. It is generally considered that this scale deposit becomes serious at temperatures above 150° F. If higher temperatures are needed the installation of a water softener should be considered.

Many farmers are making their own electric water heaters by installing side-arm heaters or immersion heaters on range boilers. If this is correctly done, the heaters can be satisfactory. However, too often these heaters are homemade for the purpose of greatly cutting costs and things essential to satisfactory, economical operation are omitted. They usually are inadequately insulated, resulting in very high electric current consumption. Heat traps and temperature-pressure release valves are left off. Sometimes the range boiler used is old and badly corroded or scaled. If a good job is done, the cost of materials and labor in a homemade heater may equal or exceed the cost of a purchased heater.

Many so-called instantaneous electric water heaters are on the market and are being widely advertised. Probably many farm people are buying them with the expectation that these devices will furnish them adequate hot water. A little arithmetic will show that if the temperature of the water is to be raised 70° F - say from 60° F to 130° F - and it is flowing from the faucet at a rate of 5 gallons per minute (a very good flow) a 51,000 watt heating element would be needed in the heater. If the water flows at a rate of only 1 gallon per minute (inadequate for most purposes) a 10,200 watt heating element would be needed. Even without examining the heaters it is obvious that they contain no such heating elements since they are advertised for connection to ordinary appliance circuits. A 20 ampere, 115 volt appliance circuit will carry a maximum load of 2,300 watts. At best, these heaters could heat less than one quart of water per minute.

If the well water is very cold, it may be desirable to pass it through a tempering tank before it enters the heater. Commonly range boilers are used for tempering tanks and they are placed somewhere so that they will pick up some heat. This will reduce the amount of electricity necessary to heat the water.

It is desirable that the heater be located so that the hot water pipes from it to faucets are as short as practical. The water in these pipes cools when the faucets are closed and short pipes will make it necessary to draw less cold water from the faucet before hot water comes. The heat lost from the water in these pipes is wasted electricity. The pipes may be insulated but usually the faucets are opened so infrequently that the water cools even though there is insulation on the pipes. Unless the pipes are very long, insulation is seldom justified except to the kitchen sink where water is used frequently and possibly to the bathroom lavatory.

Kitchen Sinks

There are several styles of kitchen sinks. For convenience they may be classified as follows although any one sink will fall into more than one of these groups.

1. Single basin
2. Twin basin
3. Flat rim
4. Roll rim
5. Rimless
6. Splash back
7. Left hand drainboard
8. Right hand drainboard
9. Double drainboard
10. Wall hung
11. Workboard
12. Cabinet
13. Electric

The choice of a sink is largely a matter of personal preference. However, the best kitchen plans use workboard, flat rim, or rimless ones built into the work counters level with the counter tops. The most efficient kitchen plan for a right-handed woman provides for work to move through the kitchen from the right to the left. This means that if a drainboard sink were installed, the drainboard should be on the left. Similarly, a right hand drainboard would be best for a left-handed woman.

Electric sinks are cabinet sinks which come equipped with electric garbage disposal units and automatic dishwashers.

A very common size for a single basin sink is 20 inches by 30 inches. Twin basin ones are often about 20 inches by 40 inches.

Most sinks are available in either regular or acid-resisting enamel finish.

Water Closets

Water closets are classified in several ways, but if we confine our discussion to the types commonly found in homes we find two types of tanks and three types of bowls:

Tanks	Bowls
1. Wall-hung	1. Washdown
2. Close-coupled	2. Reverse-trap
	3. Siphon-jet

This same grouping covers the closets commonly found in schools, churches, and other community buildings, except that a third type of bowl used only with flush valves instead of tanks and known as blow-out is sometimes used. Flush valves are used only with siphon-jet and blow-out bowls, and are seldom installed in homes because of the large water pipes necessary to make them operate properly.

The cheapest closets usually have wall-hung tanks. These tanks are connected to the bowls by short sections of chrome-plated pipe. They require somewhat more work in their installation and by many people are considered to be not as neat in appearance as the close-coupled ones.

The close-coupled tanks are bolted rigidly to the bowls and do not require separate attachment to the walls. They are usually somewhat more expensive than wall-hung ones.

A washdown bowl can be identified by the trap in the front. The location of the trap limits the amount of water surface in the bowl and makes cleaning somewhat more difficult than with the other types.

In general, washdown closets are noisier and less expensive than other types. They depend on siphon action in the trap to empty the contents, although some of them also have a jet to assist the siphon. The siphon action is started by filling the bowl to the point where the overflow through the trap fills the trap. Discharge passages are small by comparison with the passages in siphon-jet and blow-out bowls. Figure 13 illustrates a washdown bowl without a jet.

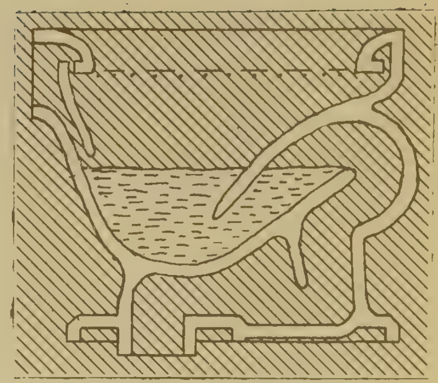


Figure 13

A reverse-trap bowl is similar to a washdown bowl except that the trap is in the back. This permits a larger water surface in the bowl with consequent easier cleaning. The action is somewhat quieter. They may or may not be equipped with jets to assist the siphoning action. The reverse-trap type is the most common for home installation. It is generally intermediate in cost between the washdown and the siphon-jet bowls. Figure 14 illustrates a reverse-trap closet.

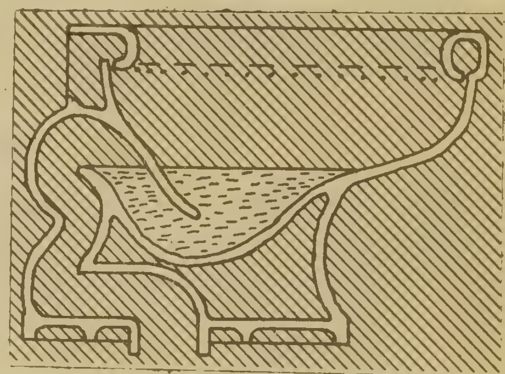


Figure 14

A siphon-jet bowl looks much the same as a reverse-trap bowl with a jet. The difference is largely a matter of degree. The water passages are larger and the water seal deeper. The jet action is much stronger. The large water seal makes it the easiest to clean. It is the quietest in action. It is generally the most expensive. Siphon-jet bowls are made both in wall outlet and floor outlet styles. Figure 15 illustrates a siphon-jet closet.

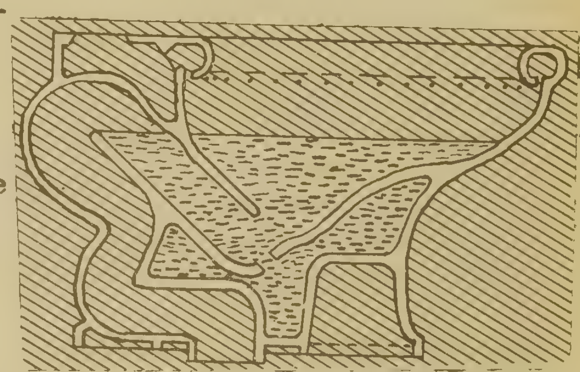


Figure 15

The action of a blow-out bowl depends entirely on a powerful jet. They are the noisiest of all types. Being limited to use with flush valves, they are better suited to schools, offices, and other public places than they are to homes.

A water closet usually requires a floor space about 24 inches by 40 inches.

Lavatories

Lavatories may be divided into four groups on a basis of the way they are mounted:

1. Wall-hung
2. Leg
3. Pedestal
4. Cabinet

The choice among these types is largely a matter of personal preference. They usually require about 18 inches by 20 inches of floor space.

Bath Tubs

Bath tubs can be grouped under three general styles:

1. Leg
2. Apron
3. Universal

The leg type is in disfavor by practically all home management specialists. It is relatively unsightly and the spaces under and around it create considerable additional housekeeping work. However, it is the cheapest type.

The apron type is most popular and also most expensive. It has an enameled skirt extending to the floor.

The universal type is installed in much the same way as the apron type but lacks the skirt. It must be walled in with waterproof wallboard or other similar material. It is intermediate in cost between the leg type and the apron type.

There are several variations in the apron type of tubs. Most of them are rectangular in shape but some are square with the basin extending diagonally across the fixture. Both the rectangular and square ones are available with the apron on one side only or on one side and one end. Those with aprons on only one side fit into a recess while those with aprons on the end too fit a corner.

Tubs come in lengths varying from about 4 feet to about 6 feet. The 5 and 5½ feet lengths are most popular.

Most tubs are made of enameled cast iron although there are also enameled sheet steel ones and glazed earthenware ones. The glazed earthenware ones are usually more expensive and are relatively very heavy.

Showers

Combination tubs and showers in bathrooms are now common. This arrangement requires a shower curtain and walls not damaged by wetting.

A shower requires about half the floor space required by a tub.

While many people want showers in their bathrooms, they are especially useful in the basement or some other place convenient to the back door where farm workers clean up when they come in from the farm work. A regular bathroom shower compartment may be used for this purpose, but if there is a concrete floor, a drain placed in the floor with a shower head and a curtain rod with a curtain attached to the wall will make a satisfactory installation.

Laundry Tubs

Stationary laundry tubs are desirable unless an automatic washing machine is used. They are usually heavy equipment. In a well-organized farm home they have a fixed place and are not moved. They should be of a quality that fits with the rest of the equipment about the home but decoration beyond simple neatness is of little consequence.

The most common laundry tubs are made of cement composition although soapstone, concrete, enameled cast iron, and glazed earthenware ones are available. The two-compartment ones are to be preferred since they provide for two rinses.

The location of laundry tubs should consider drainage as well as the availability of hot and cold water. They should be placed so that the clothes from the wringer of the washing machine can drop directly into the rinse.

Fixture Drains

The drain from a fixture leads from the fixture to the soil stack or house drain.

Every drain must include a trap. The purpose of this trap is to prevent sewer gases from getting into the room. Water closets have the traps built into them, but in all other household fixtures the traps must be installed beneath the fixture. A special trap known as a drum trap often is used on the bath tub. This trap may be installed with the top clean-out opening flush with the floor. Other fixtures use S traps or P traps which receive their names from the similarity of their shapes to the alphabetical letters. The drain from a P trap enters the wall back of the fixture while the drain from an S trap enters the floor beneath the fixture. The P traps are to be preferred because there is less danger of self-siphonage. Some codes forbid the use of S traps.

Soil or Waste Stack and House Drain

The waste from the fixture drains passes into either the soil or waste stack, or the house drain. The soil or waste stack is the vertical portion of the sewage disposal pipe in the building. It passes down

through a wall to the house drain. The upper portion above the highest fixture drain opens to the outside air through the roof or under an eave and is known as the main vent or stack vent. The purpose of this main vent is to allow sewer gases to escape to the outside air and to maintain atmospheric pressure throughout the sewage system. Fixture drains are vented individually to this main vent or to the outside air to prevent the water seal from being siphoned from the traps.

The house drain leads from the soil stack to a point at least five feet outside of the house. Local and state plumbing regulations vary widely in their requirements for fixture drains, soil stacks, vents, and house drains. Many of them are actually contradictory. But in general, a 3-inch soil stack and house drain is adequate for farm use. Many 2-inch stacks and drains have been used and are giving satisfactory service but the possibilities of trouble from careless installations with drains this small are enough that they are not to be generally recommended.

Generally, a main vent of 1-1/2" pipe is large enough, although, in some of our colder regions, it may be desirable to increase the size to 3" as it passes through the roof and into the outside air to prevent its clogging with ice and frost in the winter. Local codes and regulations should be consulted for their requirements.

The installation of house drains and soil stacks is simplified somewhat by the use of threaded rather than bell joint pipe. However, few workmen are equipped to thread pipe 3" in diameter and larger, so that its use requires accurate preliminary measurement and ordering pipe cut and threaded to fit.

Sewage Disposal Means

As a general recommendation, a septic tank with a field-drain-tile disposal field is the only acceptable means of disposing of bathroom waste, although 50 feet to 100 feet of buried 4 inch field-drain-tile will often be adequate for kitchen sinks and laundry tubs. Cesspools have been widely used but, except in rare cases, are to be avoided. The purification of sewage in the soil depends on the action of aerobic bacteria and molds. These organisms are not present deep in the soil where the air does not penetrate. The seepage from cesspools is ordinarily below this level. The seepage from cesspools is at such a depth that the probability of contaminating the ground water is much greater than when shallow field-tile disposal fields are used. In addition to the sanitary disadvantages of cesspools, the walls of the cesspool commonly become plugged with sewage after a relatively short time and it overflows on the surface of the ground. A new one must then be dug in a new location.

Septic Tanks

A septic tank is merely a closed chamber in which the sewage remains long enough for most of the solid matter to decompose into liquids and gases. The gases escape through the soil of the disposal field,

or through the house drain and the main vent. The bacteria which bring about this decomposition are anaerobic, that is, they live where there is no air. For this reason, it is necessary that the septic tank be so constructed that neither the incoming or outgoing sewage agitate the contents enough to mix air with it. This is sometimes done by placing baffles in the tank in such a manner that the flow through the incoming and outgoing pipes does not agitate the main contents. Many tanks accomplish the same thing by having the incoming sewage deposited straight downward at least 12 inches below the surface of the contents at one end of the tank and having the outgoing sewage taken straight upward from 16 to 18 inches below the surface at the other end of the tank.

The tank should be large enough to hold 24 to 72 hours of sewage, plus the accumulated scum and sludge. No septic tank should be smaller than about 500 gallons capacity. Most septic tank troubles result from small size or inadequate disposal fields. A 500 gallon tank is adequate for a two-bedroom house.

The following tables give the recommendations of the U. S. Public Health Service for septic tank sizes:

FOR INDIVIDUAL DWELLINGS

No. of Bedrooms	Capacity in Gallons	Dimensions: Width	Length	Liquid Depth	Total Depth
		ft. in.	ft. in.	ft. in.	ft. in.
2 or less	500	3 0	6 0	4 0	5 0
3	600	3 0	7 0	4 0	5 0
4	750	3 6	7 6	4 0	5 0
5	900	3 6	8 6	4 0	5 0
6	1,100	4 0	8 6	4 6	5 6
7	1,300	4 0	9 0	4 6	5 6
8	1,500	4 6	10 0	4 6	5 6

FOR CAMPS AND DAY SCHOOLS

Maximum No. of Persons Served: Camps	Day Schls.	Capacity in Gallons	Dimensions: Width	Length	Liquid Depth	Total Depth
			ft. in.	ft. in.	ft. in.	ft. in.
40	60	1,000	4 0	8 6	4 0	5 0
80	120	2,000	5 0	11 0	5 0	6 3
120	180	3,000	6 0	13 6	5 0	6 3
160	240	4,000	6 0	18 0	5 0	6 3
200	300	5,000	7 6	18 0	5 0	6 6
240	360	6,000	8 0	20 0	5 0	6 6
280	420	7,000	8 6	20 0	5 6	7 0
320	480	8,000	8 6	23 0	5 6	7 0

Single chamber tanks are adequate for most families of 10 or less persons. For larger families or institutions, two chamber tanks with intermittent discharge should be used. The second chamber is merely a reservoir into which the liquid sewage flows from the main chamber whenever sewage enters the main chamber. When the liquid sewage reaches a certain level in this second chamber, a specially designed siphon discharges the sewage to the disposal field. The purpose of this second chamber is to provide this intermittent discharge to the disposal field and thus prevent water-logging of the soil. Where less than 10 persons use the system regularly, the discharge of the sewage into the tank is infrequent enough to provide the intermittent discharge to the disposal field without the installation of the second chamber and siphon.

The sewer line to the septic tank should have a grade of 1/4 inch or more per foot. The outlet should slope about 2 to 6 inches per 100 feet.

Septic tanks may be made of concrete, tile, or steel. A well-built concrete or tile tank will last indefinitely.

The sewer line from the house to the septic tank must be water-tight and the outlet from the septic tank should be water-tight to a point at least 100 feet from the well.

Contrary to popular opinion, a septic tank does not make sewage fit to drink. It merely decomposes solids. The effluent from the tank is still sewage. Purification takes place in the soil after the sewage has seeped from the disposal tile and has been acted on by aerobic organisms.

In several states, county agents have removable septic tank forms for concrete septic tanks which they loan or rent to farmers in their counties. Some rural electric cooperatives have these forms for the use of their members. Steel forms would be most durable but due to the cost of steel most of these removable forms are made of wood. There are several different designs that are being used. Figure 16 is a construction drawing of one good type of removable form. The forms should be oiled or greased before each use to prevent the concrete adhering to the forms. Used crank case oil is good for this purpose.

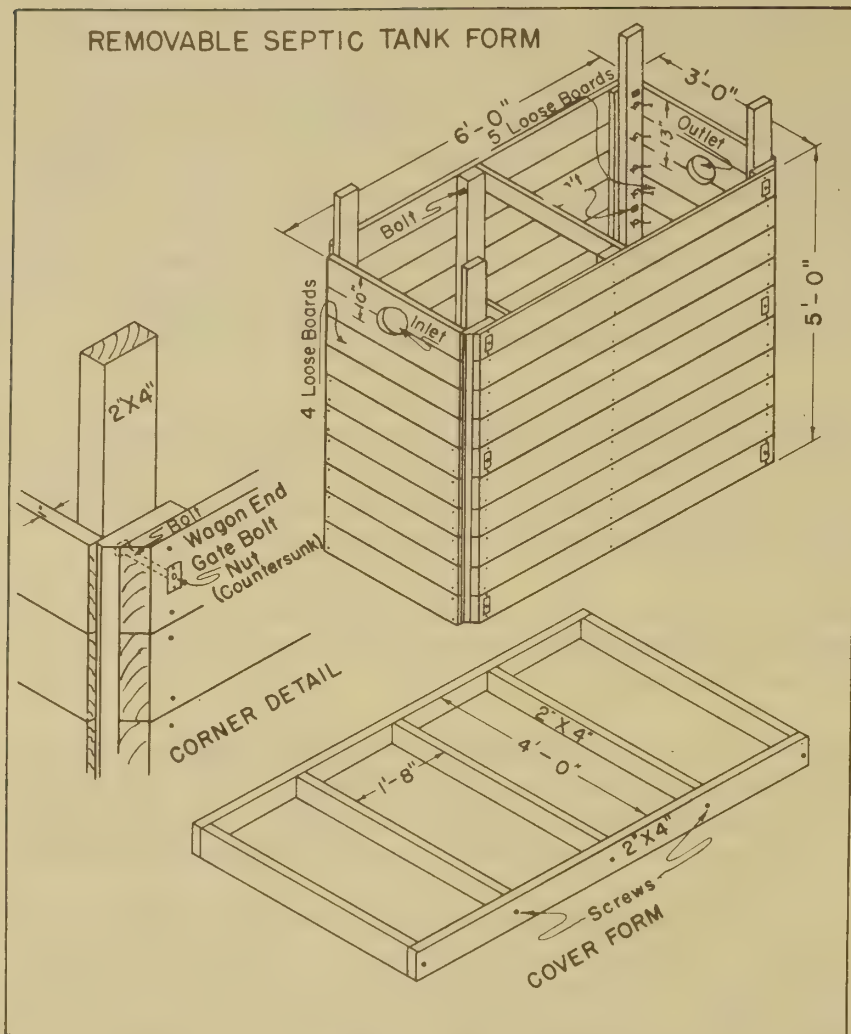


Figure 16

<u>Disposal Fields</u>

Septic tank disposal fields are commonly made of ordinary 4-inch field drain tile buried about 18 inches in the soil. Many of them consist of a single line of tile, but it is usually better practice to have the tile line fork at a distribution box into two or more branches. This will decrease the possibility of the soil near the septic tank becoming water-logged while that farther away receives no sewage. If the installation serves 10 or more people or is in very tight soil it is desirable to provide two separate disposal fields served through a distribution box with a switch. The switch permits selection of the field to be used. Changing the switch at intervals of 2 or 3 months allows each field periods of rest and tends to avoid failure of the system.

Tile lines in a disposal field should be at least 10 feet apart and no seepage should be permitted within 100 feet of a well.

As a usual thing, trees and shrubs should be cleared from the seepage area. However, if the system is carefully built, their roots may not interfere and may actually help the operation. This requires a deep bed of porous gravel under the tile so that all liquids will quickly drain from the tile. The roots may then grow into the gravel and absorb moisture but not enter the tile. Lawns and gardens are ordinarily good locations for disposal fields.

The amount of tile needed in a disposal field depends on the soil, the amount of sewage handled and the width of the trench in which the tile is placed. The U. S. Public Health Service suggests that there be at least 6 inches of porous gravel under the tile and 2 inches over it. With this porous bed of material around the tile, the rate at which the soil will absorb the effluent depends as much on the width of the trench as it does on the length. For this reason, the recommendations of the U. S. Public Health Service specify the number of square feet of gravel in the bottom of the disposal trench rather than the length of the tile lines. However, it is recommended that no single tile line be more than 100 feet long.

A soil percolation test is recommended for determining the number of square feet of gravel in the bottom of the trench. Here is the percolation test recommended by the U. S. Public Health Service:

1. Dig a hole 1 foot square and to the depth of the proposed trenches.
2. Fill the hole with water to a depth of at least 6 inches. Allow the water to seep away.
3. Record the number of minutes required for the water to seep away and divide the number of minutes by the number of inches to get the time required for the water level to drop 1 inch.
4. Repeat this test at several places throughout the proposed disposal field area so that the tests are truly representative of the area, and calculate the average time for the water level to drop an inch.
5. Use the following table to determine the square feet of gravel needed in the bottom of the trenches for each bedroom in the house or each person in a school or camp:

Minutes for Water to Fall 1 Inch	Square Feet of Gravel		
	House Per Bedroom	Camp Per Person	School Per Person
2 or less	50	13	9
3	60	15	10
4	70	18	12
5	80	20	13
10	100	24	18
15	130	32	21
30	180	45	30
60	240	60	40
Over 60	Get special advice from local authorities.		

6. For a home, multiply the number of square feet obtained from the above table by the number of bedrooms in the home to get the number of square feet of gravel needed in the installation. The minimum installation should have 150 square feet.

Ordinarily, the tile in the disposal field should be placed from 18 inches to 36 inches deep. This is true for all parts of the country. If it is deeper than this the sewage is released below the depth of great quantities of aerobic bacteria which act on it and purify it. Even in Northern Canada, disposal fields with the tile 18 inches deep seldom freeze when they are in regular daily use. Investigation of frozen septic tank systems usually reveals unusual conditions such as standing idle for a few days, sewer without any special protection under a driveway, or a line plugged for some other reason so that the frozen part is wholly or partly inactive before it freezes.

Grease Traps

There is considerable discussion and disagreement among sanitation experts throughout the country as to the value of grease traps. The U. S. Public Health Service does not favor their use for ordinary residential installations. There are two reasons for this. For proper operation they require periodic attention which they almost never get at a private residence. If they do not get this attention they become clogged and create a health hazard. The second reason is perhaps most significant. If the septic tank is adequate in other respects, it will handle all normal household grease without appreciable effect so that the grease trap provides no useful service. In institutions where a considerable amount of grease is discharged with the sewage and where regular maintenance service is provided through janitors or building engineers, grease traps may be desirable.

Dairy Water Heaters

Dairy water heaters are commonly of two types -- the small portable type and the storage type similar to domestic water heaters. The choice will depend on the individual situation.

Watering Troughs

Concrete, steel, and wooden watering troughs are most common. The concrete ones are the most durable and generally to be preferred. The water level in the trough can be maintained by a float controlled valve on the water line to the trough, or the trough can be filled by a manually controlled hydrant. If it is manually controlled, a frost-proof hydrant is to be preferred. Such hydrants are so built that when they are shut off a valve is opened below ground level and all of the water in the riser from the underground pipe is allowed to drain away in the soil.

Individual Livestock Drinking Cups

Continually available water definitely increases the milk production of dairy cows. Individual drinking cups also decrease the labor necessary in handling the dairy herd. An adequate installation usually consists of one cup for each two stanchions. Two cows thus use one cup.

Wiring For Pump Motors

The way wiring is installed around devices that handle water is unusually important. While pure water is a fairly good insulator, wet objects and water with certain materials in solution are conductors of electricity.

Water system pump motors are particularly susceptible to burning out under low voltage conditions. In past years many of them were not equipped with overload protection. The industry is highly competitive and each manufacturer is very anxious that his systems have as great capacity as other manufacturers' systems with the same size motors. For this reason, the systems have pumps which fully load the motors under normal voltage. Manufacturers have long realized that most pump motors do not run often for long periods of time. When jet pumps (which are relatively inefficient) became common they took advantage of these short periods of operation and many of them deliberately overloaded their jet pump motors so that the operating efficiencies would appear to be more nearly equal or superior to other types of pumps. This has resulted in systems on which the motors may burn out under normal voltage conditions if they run continuously for extended periods of time. Low voltage aggravates the situation still more. This makes it importent that the wiring to pump motors be installed for a minimum of voltage drop. It is best that the motors be on separate circuits with wiring designed for not more than one percent voltage drop.

Some water systems come equipped with appliance cords and ordinary 2-prong plugs for connection to ordinary convenience receptacles. For best installations these cords and plugs must be removed and permanent wiring connected into the automatic motor switches.

There should be a disconnect switch through which the motor feeds mounted near the pump. If the motor is not equipped with overload protection, such protection should be included with this switch. For a motor smaller than one horsepower the switch may be an automatic circuit breaker which will also give the overload protection. Time-lag fuses of the correct size should be used with other types of switches. An ordinary plug fuse will not give the needed protection since one that is large enough to permit the motor to start will not give running protection.

Since there is always a certain amount of moisture around a pump, electrical grounding is especially important. One of the best methods is to feed the pump motor through a 3-wire cable and to use the third wire in the cable for grounding. One end of this third wire is connected to the motor frame and the other end to the ground at the disconnect switch.

Sometimes the mistake is made of attempting to ground through the well pipe or the water pipe to buildings. The well pipe is seldom an adequate ground. The water in the well insulates it from contact with the earth.

Underground pipe of farm water systems may or may not make good grounds. They are seldom buried more than three or four feet in the ground. Many cases are known of serious shocks being received from pipes that are buried in the ground for several hundred feet of their length. Grounding to them should always be supplemented by grounding to driven electrodes. The steel pipes of municipal water systems can be depended on to make good grounds.

It is desirable that the pump motor be on an individual service from the yard pole and connected ahead of the main breakers or fuses serving other buildings. Underground services to the pump house are becoming more common. While this method of serving the pump motor is more expensive to install, it does insure that the pump will not be stopped by fire in another building which destroys the wiring or opens the breakers serving that building.

Wiring For Water Heaters

Water heaters should be on individual circuits but those circuits do not always need to be of exceptionally heavy wire. Many of them are adequately served with No. 12 wire. The wire sizes needed are determined by the wattage of the heating elements and the wire length. For example: a NEMA standard 52 gallon, twin-element heater has a 1,000 watt lower element and a 1,500 watt upper element. If both elements are on together on a 230 volt circuit, the 2,500 watt load will require a current flow of somewhat less than 11 amperes. The National Electric Code allows up to 20 amperes as the safe load on a No. 12 wire, and a No. 12 wire, 230 volt circuit must be over 60 feet long before a 11 ampere load on it will cause a voltage drop of more than 1 percent. A No. 12 wire, 230 volt circuit will carry its maximum safe load of 20 amperes 30 feet without exceeding 1 percent voltage drop.